FILE# 02228

MEMORANDUM RECEIPT

22 JULY 1968
DATE

STAT TO: [redacted]

STAT FROM: [redacted]

SUBJECT: Equipment Loan

I hereby acknowledge receipt of the following:

STAT 1 [redacted] Stereo Comparator Head with 1PR [redacted] 10X Objectives STAT

GA-448

1PR	[redacted]	10X Objectives
1PR		6X Objectives
1PR		3X Objectives
1PR		6X Eyepieces
1PR		10X Eyepieces
1PR		10X Objectives

(To be returned in 6 months)

[redacted] STAT

SIGNATURE OF RECIPIENT

Please return 1 signed copy(ies) of this receipt

STAT To [redacted] PO Box 8031 Southwest Station, Washington, D.C. 20024

July 1968
DATE RECEIVED

FORM NO. 752 REPLACES FORM 36-66
1 AUG 55 WHICH MAY BE USED.

(33)

TWIN STAGE COMPARATOR - RETICLE SELECTION

Summary: Consideration of the available alternatives leads to the recommendation for the vertical bar-dot-bar pattern in both eyepieces provided that the alignment requirements can be met. If the necessary alignment is not feasible, an acceptable alternative is to provide the horizontal pattern in one eyepiece and the vertical bar-dot-bar in the other. These recommendations apply only to the subject equipment development and must not be used in other applications without further study.

Design Alternatives: Three reticle designs have been defined as possible alternatives. These are shown in Figure 1. One of these options is to be selected for each eyepiece; they need not be identical. The possibility of a colored reticle is also to be considered.

Design Selection: The following criteria were used to compare the available alternatives:

1) Detectability of the 20 μm dot (the actual measuring point) must be maximized.
2) Fusion of the dots must be easily and accurately achieved and maintained.

The addition of the bars in options 1 and 2 is clearly desirable for enhancing the detectability of the dots. Option 3, therefore, need not be considered unless the presence of the bars is found to interfere with accurate measurement.

There are three possible combinations of options 1 and 2.

<u>Option 1 in one eye - Option 2 in the other:</u>

With this configuration, there is no fusion of the bars and consequently no tendency to attempt to fuse the entire pattern. Total fusion could be a problem if misalignments in reticle positioning are present. Use of two different configurations, however, will

OPTION 1

OPTION 2

OPTION 3

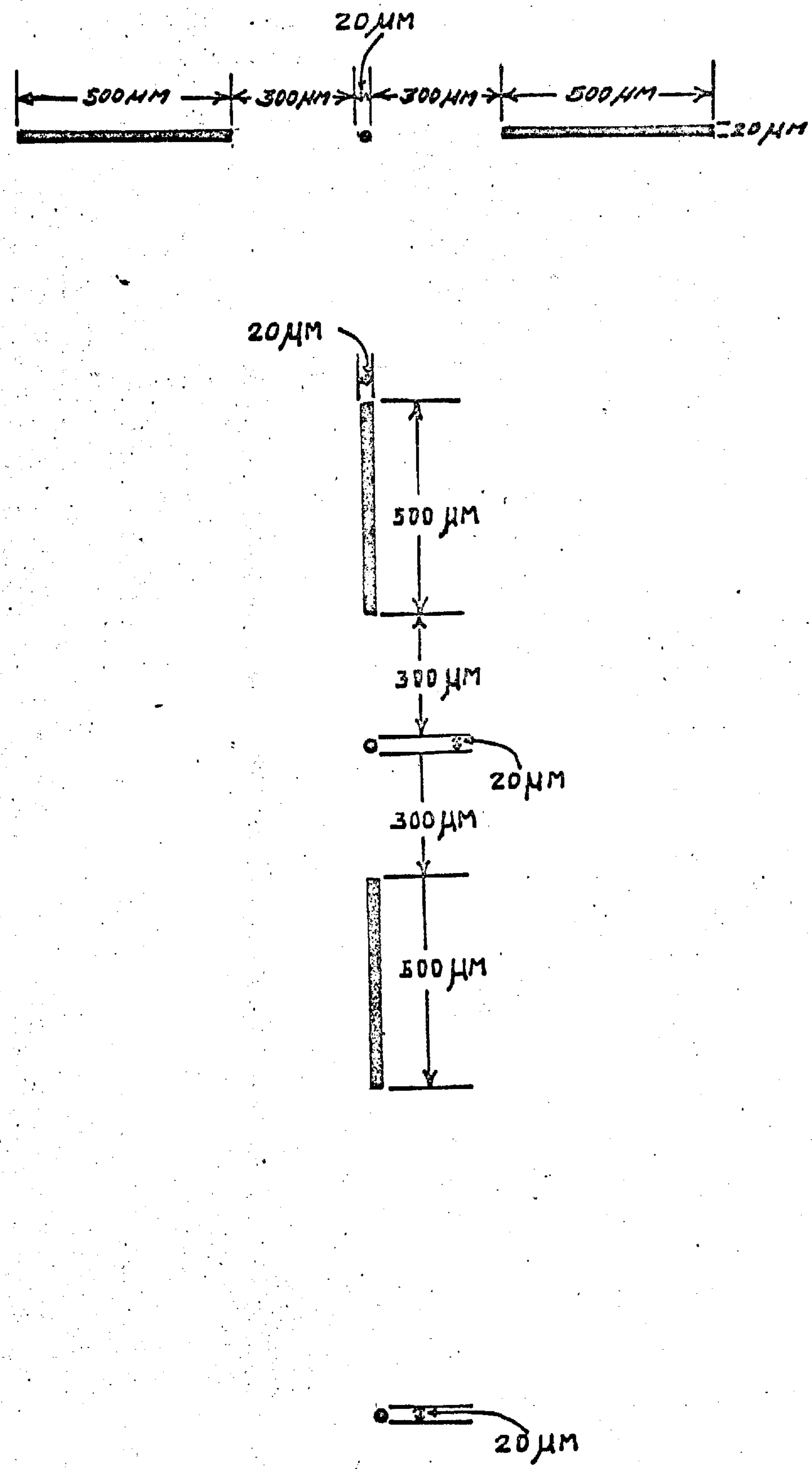

FIGURE 1: RETICLE DESIGN OPTIONS

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intorudce problems of binocular rivalry. Fusion of the dots, once located, will suppress this rivalry (Ogle and Wakefield, 1967), but until the dots are perceived the binocularly seen "cross" will tend to be unstable both in configuration and contrast (Kaufman, 1963). This effect will be disturbing and fatiguing but, for this application, it is not expected to create a serious problem.

Option 2 in both eyes:

With the same pattern in each eye, binocular rivalry will be minimized. There will, however, be problems of conflict between the bars and dots unless the reticles are adequately duplicated and aligned. In order to permit fusion of the entire pattern, the individual elements of both patterns must be aligned within the limits shown in Table 1.

TABLE 1: RETICLE PATTERN ALIGNMENT REQUIREMENTS

Direction	Visual Angle Tolerance	Reticle Dimensions
Vertical	17 min ①	.127 mm
Horizontal (convergent)	1 deg 44 min ①	.762 mm
Horizontal (divergent)	34 min ①	.254 mm
Rotational	n.a.	3 degrees of arc ②

Assumes: far point accommodation
10x eyepiece

Reticle dimensions = tan (visual angle) x $\frac{250 \text{ mm}}{10}$

① Ref: Boeing, 1968

② Estimate, no data available

Although the above tolerances will allow the entire pattern to be fused, the bars will appear in a different plane than that of the dot, unless all of the elements are aligned within a tolerance of 0.25 μm. If such alignment can be achieved and maintained, this alternative is the preferred one because of the ease with which the entire pattern can be fused.

Option 1 in both eyes:

Minimum binocular rivalry will result. The horizontal direction of the bars will result in less difficulty if small misalignments exist but is less effective in aiding fusion of the pattern.

The use of color appears to have considerable merit for improving the detectability of the dots. Two problems, however, preclude such use for this application. First, some question remains concerning the effect of chromatic aberration in the eye on measurement accuracy with monochromatic dots. Secondly, if the color is to be effective, the reticle must be self luminous or internally illuminated. The practicality of such an approach does not appear to be attractive.

Conclusion: If the individual elements of both reticles can be positioned within a tolerance of 0.25 μm, the vertical bar-dot-bar pattern is preferred for both eyepieces. If the positioning requirement cannot be met, the vertical pattern in one eyepiece and the horizontal in the other is recommended.

REFERENCES

Boeing Company, 1968, "Human Engineering Design Guide for Image Interpretation Equipment," Seattle, Washington.

Kaufman, L. 1963, "On the Spread of Suppression and Binocular Rivalry," Vision Research, Vol. 3. pp 401-415.

Ogle, K. N., and Wakefield, J. M., 1967, "Stereoscopic Depth and Binocular Rivalry," Vision Research, Vol. 7 pp 89-98.

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From

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TWIN STAGE COMPARATOR - REVIEW OF PRELIMINARY OVERALL PHYSICAL CONSIDERATIONS

SUMMARY: Review of the comparator preliminary overall physical considerations as presented in drawing no. 1740-P1 provided the following comments:

1. Eyepiece height is not satisfactory and must be lowered at least 1½ inches.
2. Kneewell depth is minimal - an increase of at least 1 inch is recommended.
3. Provision of writing surface, arm rests, and control placement is complicated by the optical system configuration. Careful consideration of these problems is essential.

DESIGN CONSTRAINTS: The expected operator population includes 90% of the U.S. adult population under 60 years of age. To be consistent with available anthropometric data the above condition is interpreted as including the upper 95% of the female population and the lower 95% of the male population. Relevant dimensions for the extremes and for representative members of this population are shown in Table 1.

TABLE 1: CRITICAL OPERATOR DIMENSIONS (INCHES)[1]

	Sitting Eye Height[2]	Knee Height[3]	Popliteal Height[3,4]	Buttock-Knee Clearance	Thigh Clearance
5^{th} Percentile Female	26.5	19.5	15.5	20.5	4.0
50^{th} Percentile Female	29.0	21.0	17.5	22.5	5.5
50^{th} Percentile Male	30.5	22.5	18.5	23.5	6.0
95^{th} Percentile Male	32.0	24.5	20.5	25.5	7.0

1 - data from U.S. Dept. of H.E.&W. (1965)

2 - measured from seat reference point

3 - includes allowance for shoes (1 inch for men, 1.5 inches for women)

4 - distance from bottom of the foot to the sitting surface.

An additional constraint on operator positioning is imposed by the decision to use available chairs for seating. Standard adjustible office chairs can be varied in height from 15 to 19 inches.

EYEPIECE HEIGHT: A nominal eyepiece height of 48 inches is indicated in the drawing. This distance was apparently selected on the basis of data presented on page 4-29 of the Boeing "Human Engineering Design Guide." The data presented in the guide are unfortunately not entirely appropriate to this application. The text accompanying the data in the guide says that "each console must be 'tailor-made' to fit the operational requirements . . ." The data used from page 4-29 are for a "typical" console where precise eye positioning is not a critical consideration. In the present situation, where the operator's eye must be located exactly at an eyepiece, the console must be sized to the smallest rather than the average observer as is the case for the configurations shown on page 4-29. The reason for this is that an operator can slump to use an eyepiece that is too low; he cannot stretch to use one that is too high.

For the dimensions shown in the subject drawing the eyepoint for the eyepiece at minimum elevation will be about 47 inches above the floor. To reach this height the small operator (5th percentile female) will need a chair 20½ inches in height. This will require a custom built chair and may introduce thigh clearance problems. The average thigh clearance for the small operator is 4 inches which allows only ½ inch tolerance to the top of the knee well.

A reduction in nominal eyepiece height to 46½ inches will permit the use of standard adjustible type chairs. At this height, the largest operator will have to lower his chair at least 2 inches. A footrest of up to 3½ inches high will be required for smaller operators.

If a further reduction to a 44 inch eyepiece height is possible, the need for adjusting seat height can be minimized or perhaps eliminated. This is especially desirable to minimize set-up for instruments used by a number of different operators. With a 44-inch eyepice height (at 30°

elevation) and a fixed seat height of slightly over 17 inches, the largest operator will need to slump about 4 inches at maximum eyepiece elevation. This is not excessive except for prolonged operation. A footrest of up to $1\frac{1}{2}$ inches will be required for some operators.

KNEEWELL DIMENSIONS: The fifteen-inch depth shown in the drawing may create problems for this instrument. Fifteen inches is adequate for typical control console operation (see page 4-29 in the Design Guide) but is marginal for this situation, particularly where the required eyepoint is located approximately 1 inch inside the edge of the table. If possible, this dimension should be increased to at least 16 inches. In any event all surfaces within the kneewell must be smooth; sharp edges and corners must be avoided.

WORK SURFACE: There is no provision for a writing surface or for the display of collateral materials. This problem can be solved with the use of an auxilary table but layout arrangement including the con- STAT
sole and teletypewriter should be considered.

CONTROL PLACEMENT: The preliminary configuration does not appear to offer any acceptable locations for controls that must be used while viewing (e.g., joystick), nor any acceptable surface on which the operator can rest his arms. Arm rest is essential for effective maintenance of eye position and for precise control positioning. Because of the configuration of the optical system, solutions to this problem are not obvious. The table surface could be extended to form "wings" on either side of the kneewell (20 inches between the "wings" is preferred). Control areas could conceivably be located on the table surface at each end of the comparator mechanism. This location is well beyond the recommended control placement area (see Figure 1).

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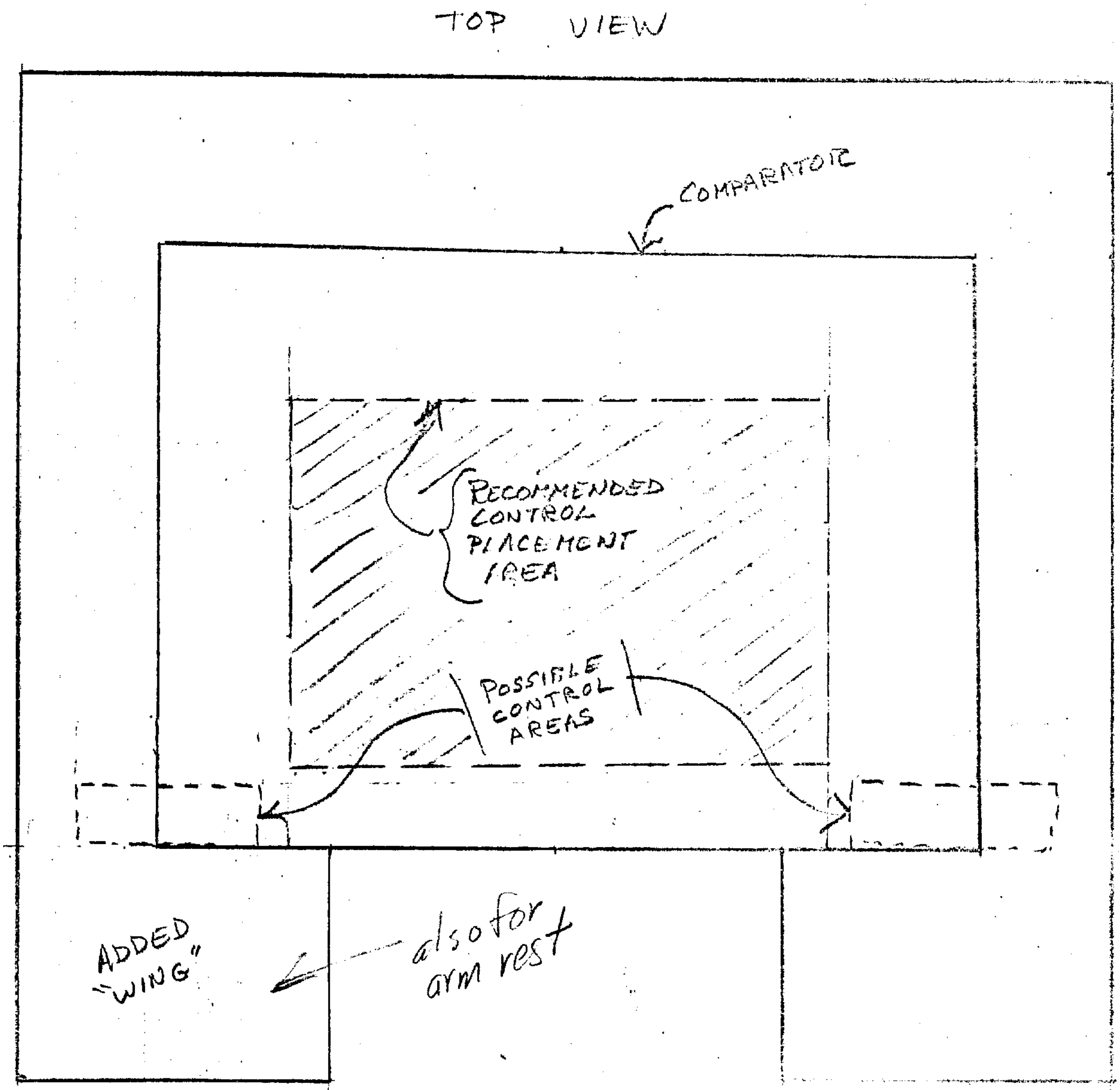
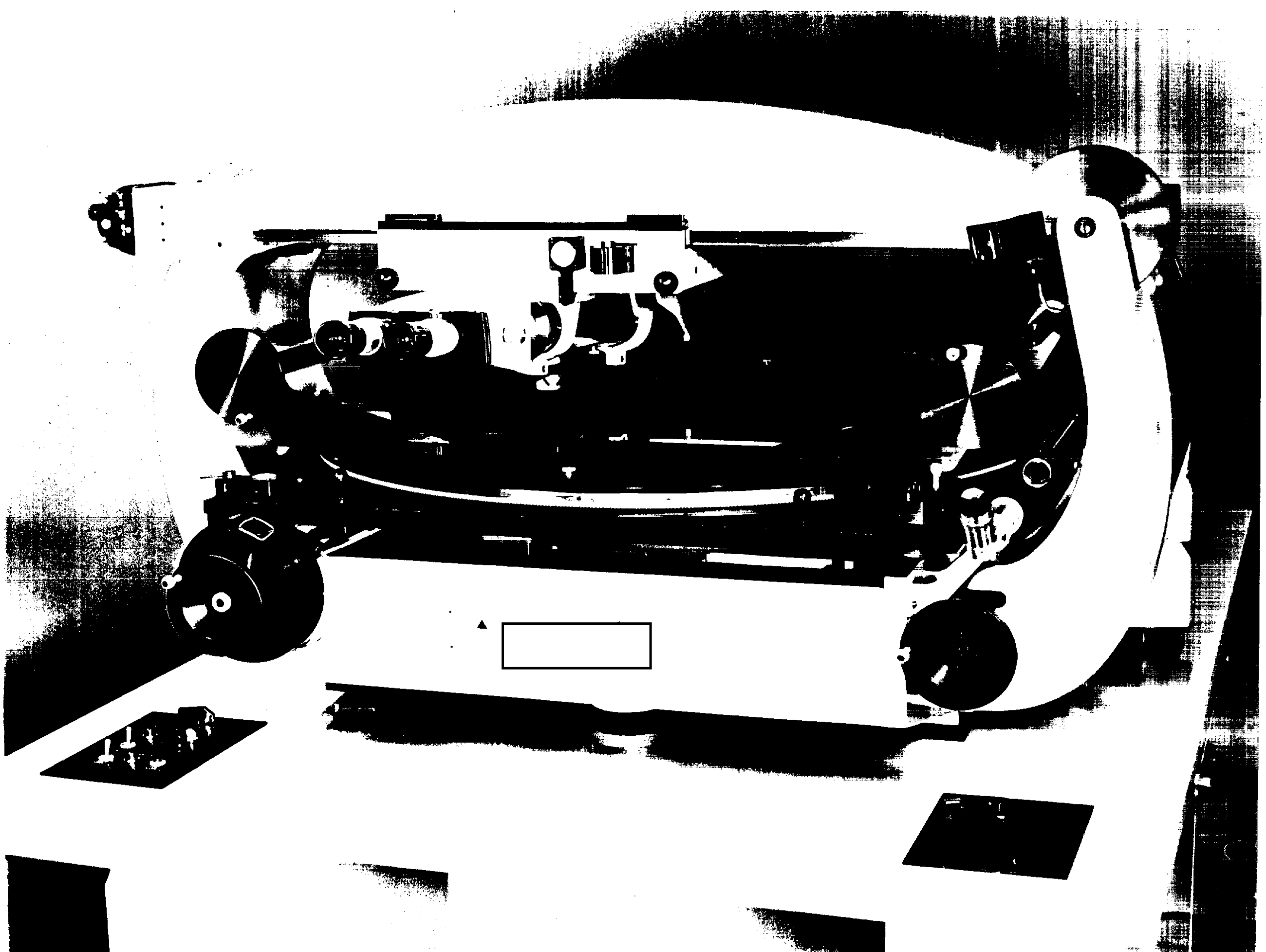


Figure 1: Control Placement Considerations



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TECHNICAL DESCRIPTION

AND

DESIGN OBJECTIVE FOR

STAT [redacted]

HIGH POWER STEREO COMPARATOR HEAD

This instrument is to be used as the optical viewing subsystem of a photographic measuring instrument. It is a major redesign of the High Power Stereoviewers manufactured on previous contracts with the U. S. Government. The primary change is in the optical system, to enable the reticles to be placed in an intermediate image plane, rather than in the eyepieces where they can be displaced when adjusting the Interpupillary Distance (IPD). Mechanical changes are required to accommodate the optical changes. In addition, the eyepiece angle will be adjustable.

The instrument consists of two [redacted] DynaZoom Laboratory Microscopes coupled with an optical system to form a stereoviewer. The DynaZoom pod has a continuously variable magnification from 1X to 2X. With 5X and 10X eyepieces and 2.6X, 3.5X, 6X and 10X objectives, a magnification range from 13X to 200X is covered. The 3.5X and 6X objectives are not both needed to cover the magnification range, but the 3.5X objective gives a wider field and the 6X objective gives higher resolution. STAT

Each optical system consists of an objective, the zoom elements, a penta prism to direct the path horizontally, an image rotation prism (Pechan), reticle, a field lens, a mirror to incline the path toward the eyepieces, a 1X relay lens, a field lens and finally the eyepiece.

Following are the objectives used with this instrument:

Catalog #	Magnification	Focal Length	Numerical Aperture
31-10-07	2.6X	40mm	0.08
31-10-06	3.5X	30mm	0.09
31-10-18	6 X	22.7mm	0.17
31-10-17	10 X	16mm	0.25

The objective lenses are mounted in a four-position centerable nosepiece. The 3.5X, 6X and 10X objectives are parfocal and require very little refocusing when changing objectives.

The zoom is adjusted by means of a knob on the top of each pod. It is graduated from 1X to 2X in tenths.

The housing above the zoom system has been redesigned and, due to the complexity of the penta prism mount, the ability to provide monocular viewing or photomicrography has been omitted.

The Pechan prism rotates the image continuously without limit. 180° rotation of the prism rotates the image 360°. The prism mount has a knurled knob for turning and numbers to indicate approximately the amount of image rotation.

The reticle is mounted in a two-position slide, so that the reticle may be moved out of the field of view. The reticle will consist of an engraved and filled black dot, 0.016± .004mm, in the center of the field.

The IPD of the eyepieces is adjustable by means of a lever through a range of 55 to 72mm. The eyepieces are nominally 30° to the horizontal and are adjustable ± 7-1/2° for operator convenience.

Adjustment of the eyepiece angle causes image rotation. A graduated scale reads the eyepiece angle. This angle must be transferred to a slip ring to set the "Zero" index for the Pechan prism which automatically compensates for the image rotation due to changing the eyepiece angle.

The centers of the objectives will be nominally 12.102 inches apart. Dimensions for mounting to the comparator are shown on the enclosed outline drawing, (D588337-003).

During the course of a measurement sequence, the Zoom knob and the image rotation prism must not be rotated. The nosepiece must not be rotated nor the centering adjustment moved.

Following are the eyepieces to be used:

Catalog #	Magnification
31-05-03	5X
31-05-60	10X W.F.

Resolution, field of view, etc., depend on the combination of eyepiece and objectives used and the position of the zoom system. The following table gives the nominal field size for combinations of the above listed eyepieces and objectives when the zoom is at 1X. When the zoom is at a position other than 1X, the total magnification is multiplied by the zoom magnification, and the field is divided by the zoom magnification.

Eyepiece	Objective	Magnification	Field
5	2.6	13	7.0mm
5	3.5	17.5	5.2mm
10	2.8	26	7.0mm
5	6	30	3.0mm
10	3.5	35	5.2mm
5	10	50	1.8mm
10	6	60	3.0mm
10	10	100	1.8mm

Resolution cannot be conveniently expressed as so many lines per millimeter per power, because of the interchange of objectives and eyepieces.

Each eyepiece, zoom system and objective will be inspected in test fixtures and will meet the rigid [redacted] Quality Assurance standards for a DynaZoom Laboratory Microscope. These tests include resolution,coma, astigmatism, etc. STAT

With the 10X eyepieces, the zoom at 2X and the 10X objective, the instrument will have an axial resolution of approximately 700 lines per mm.

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